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Combined Transmission of Baseband NRZ-DQPSK and Phase Modulated Radio-over-Fibre

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Abstract

21.4 Gbit/s baseband DQPSK and 1.25 Gbit/s phase modulated RoF was transmitted over 80 km SSMF using polarization multiplexing.

Introduction

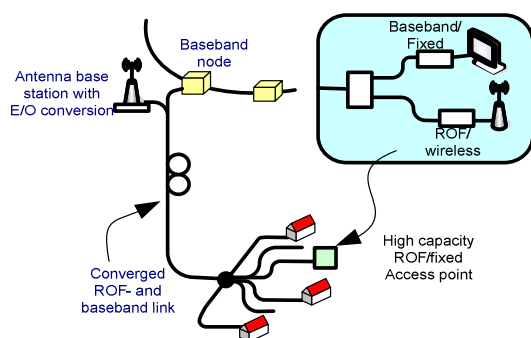


Figure 1: An illustration of the combined RoF/baseband network

There is an increase in the demand from broadband telecommunication end-users to have instant access to their multimedia applications, whether it is from a fixed or a mobile terminal. Therefore, the transport of radio-over-fibre (RoF) signals and high speed baseband signals over a shared optical infrastructure is foreseen to pave the way to a seamless and flexible broadband solution for the end-user. We propose and investigate experimentally a scheme for transmitting a phase modulated RoF [1,2] signal along an existing fibre infrastructure without degradation of the existing baseband signal. The baseband signal is non return to zero (NRZ) differential quaternary phase shift keyed (DQPSK) [3] at a bit rate of 21.4 Gbit/s and a symbol rate of 10.7 Gbaud. The optically phase modulated RoF signal is generated by driving an electro-optic phase modulator with the radio signal received at the antenna base. Separation of the RoF- and baseband signals is achieved by the use of polarization multiplexing. Using the proposed scheme, the RoF signal was transmitted over an 80 km standard single-mode fibre link along with the co-propagating NRZ-DQPSK baseband signal. The use of phase modulation in the optical domain for both signals enables the employment of identical receiver structures for both. Moreover, the RoF transmitter can be made very simple as, contrary to the case for intensity modulated RoF, there is no need for bias control of the phase modulator.

Experimental setup

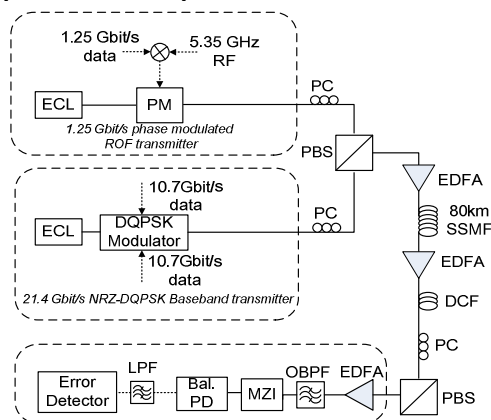


Figure 2: Experimental setup. Noise loading and OSNR measurement has been omitted for the sake of simplicity.

A simplified block diagram of the experimental setup is illustrated in figure 2. An emulated RoF signal at 1.25 Gbit/s is generated by electrical mixing of a 1.25 Gbit/s data signal and a 5.25 GHz radio frequency (RF) carrier. The combined signal is applied to a phase modulator (PM) in order to phase modulate continuous wave (CW) light at a wavelength of 1556.07 nm from an external cavity laser (ECL). 21.4 Gbit/s NRZ-DQPSK modulation is applied to the CW output of a second ECL at a wavelength of 1555.94 nm. The wavelength difference between the two signals is caused by the limited tunability of the lasers used in the experiment. The NRZ-DQPSK modulation is performed by a dual Mach-Zehnder modulator driven by two 10.7 Gbit/s electrical data signals. Pseudo random bit sequences (PRBS) with a word length of

2^7-1 and $2^{11}-1$ were used for the baseband signal and the RoF signal, respectively. The 2 signals were polarization multiplexed in a polarizing beam splitter (PBS), and launched to a transmission span consisting of 80 km standard single-mode fibre (SSMF) and 13 km dispersion compensating fibre (DCF).

Polarization de-multiplexing was performed by another PBS before detection by a pre-amplified

receiver setup consisting of an erbium doped fibre amplifier (EDFA), an optical band-pass filter (OBPF) with a 3 dB bandwidth of 0.4 nm, a Mach-Zehnder delay interferometer (MZI) with an FSR of 10.7 GHz, a pair of balanced photodiodes (PD) and an error detector. For the reception of the RoF signal, the MZI converts the phase information to amplitude information and suppresses the 5.25 GHz RF carrier. This was done by tuning the phase off-set between the two arms of the MZI so that the notch point of the MZI transfer function was at the carrier frequency of 5.25 GHz. After that, the high-order copies of the signal were removed by an electrical low-pass filter (LPF) with a cut-off frequency of 1.8 GHz. For the reception of the NRZ-DQPSK modulated baseband signal, the MZI is operated at quadrature points in order to get the two DQPSK tributaries. In a real implementation of the proposed scheme, 3 MZIs would be required: 2 for the NRZ-DQPSK demodulation and 1 for the RoF demodulation. In the experiment, only one was used, and the 3 signals were measured one after the other. Before the receiver, the signal was loaded with noise from an open-ended EDFA, and the optical signal to noise ratio (noise bandwidth = 0.1 nm) was measured with an optical spectrum analyzer (OSA).

Results

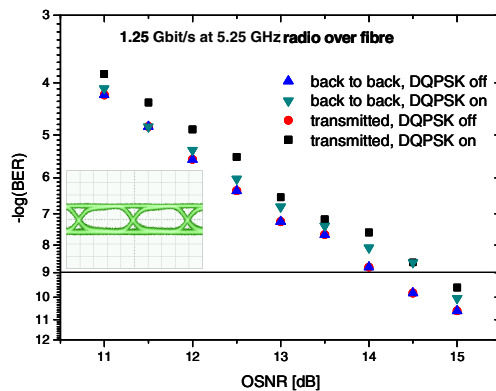


Figure 3: BER of the 1.25 Gbit/s RoF signal before- and after transmission, with- and without the co propagating NRZ-DQPSK signal.

The measured BER of the 1.25 Gbit/s RoF signal before- and after transmission is plotted in figure 3 along with the eye diagram of the demodulated signal after transmission. The measured results with- as well as without the NRZ-DQPSK baseband signal present are plotted. The required OSNR for a BER of 10^{-9} was 14.0 dB without the baseband signal and 14.6 dB with the baseband signal, corresponding to a penalty of 0.6 dB. In both cases, the transmission induced no degradation of the signal, which is confirmed by the clear and open eye diagram.

In figure 4, the BER before and after transmission of the 21.4 Gbit/s NRZ-DQPSK baseband signal with and without the RoF signal is plotted. The total BER of the NRZ-DQPSK signal was calculated as the average of the 2 tributaries. There was no degradation caused by the RoF signal, and the transmission introduced no penalty. The OSNR requirement at a BER of 10^{-9} was 18.5 dB in all cases. The demodulated eye diagram after transmission is embedded in the figure and, as for the RoF signal, the eye is clear and open.

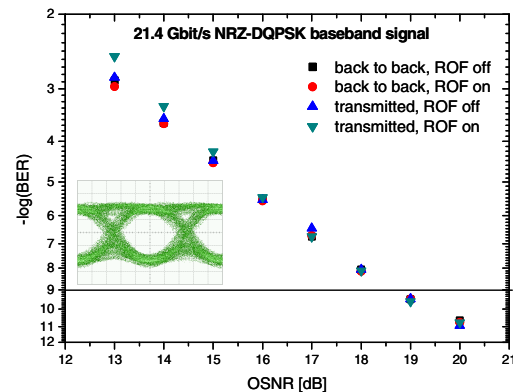


Figure 4: BER of the 21.4 Gbit/s NRZ-DQPSK baseband signal before- and after transmission, with- and without the co propagating RoF signal

Conclusions

An experimental demonstration of a converged radio over fibre (RoF) and baseband link has been presented. In the optical domain, phase modulation of a 5.25 GHz carrier amplitude modulated at 1.25 Gbit/s was used for the radio over fibre signal. The baseband signal was a 21.4 Gbit/s NRZ-DQPSK signal. The signals were polarization multiplexed, transmitted over 80 km standard single mode fibre, and received error free. For both signals, there was no penalty from the transmission. The baseband signal induced a small penalty of 0.6 dB on the RoF, however for the baseband signal, no degradation was measured from the RoF signal. The OSNR requirement at a BER of 10^{-9} was 18.5 dB for the baseband signal. For the RoF signal, OSNR requirements at a BER of 10^{-9} were 14.6 dB with the baseband signal and 14.0 dB without.

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